ried away, and along the lower river there was considerable damage to bridges, farm lands, and railroad property.

Heavy rains on the 18th caused a marked rise in the Neosho River. The rise came very rapidly, but it was nevertheless possible to issue warnings for flood stages at Oswego, Kan., by January 20, and for continued high water at Iola, Kans. Stages of 13.4 feet and 21.0 feet were reached at Iola and Oswego, 3.4 and 1.0 feet, respectively, above flood stages. No damage of great consequence was reported, altho the smaller streams overflowed their banks in many places.

Flood stages also occurred in the White River of Arkansas. There were two floods in the upper river, and one in the lower. Warnings were issued on the 3d and 10th, and no damage was done along the upper river. At Clarendon, Ark., the river remained above the flood stage of 30 feet from the 5th to the 26th, inclusive, with a crest stage of 32.5 feet from the 9th to the 11th, inclusive, but the only loss reported was that of about two hundred head of cattle and some hogs in the bottoms near Clarendon.

The Willamette River flood from the 4th to the 6th, inclusive, was checked by cold weather, resulting in stages somewhat lower than had been at first anticipated, and, at the same time, reducing the damage to a minimum. The flood was caused by the heavy rains from the 2d to the 4th, inclusive, falling upon an already saturated watershed, and the outlook was very serious until the arrival of the cold weather. As it was, flood stages were exceeded, except along the extreme lower reaches, but not to the extent that had at first been indicated.

At the end of the month the Missouri River was practically frozen as far south as Omaha, and the ice was 11 inches in thickness at Sioux City, Iowa. The Mississippi River was frozen to Leclaire, Iowa. Floating ice reached to only a short distance below Cairo.

The New England rivers remained generally frozen, while the Lehigh and upper Delaware were closed for a portion of the month.

The highest and lowest water, mean stage, and monthly range at 291 river stations are given in Table VI. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

THE KINGSTON EARTHQUAKE.

By Prof. C. F. MARVIN. Dated January 22, 1907.

The following bulletin, prepared at the Weather Bureau, was given to the press associations on the afternoon of Tuesday, January 15, 1907, at a time when, according to the earliest dispatches, a great earthquake was supposed to have occurred at Kingston on that day; whereas it will be noted that the record referred to in this bulletin relates to Monday, January 14. It finally turned out that the earthquake had actually occurred twenty-four hours before news of it reached the United States, owing to the complete interruption of telegraph and cable communications.

The seismographs at the Weather Bureau recorded a distant earthquake, of moderate intensity, on the afternoon of January 14, 1907, beginning at 3 hours 38 minutes 23 seconds p. m., seventy-fifth meridian time, or 8 hours 38 minutes 23 seconds, Greenwich meridian. The relatively stronger portion of the motion was greatest in the east-west component and lasted from 3:45 p. m. until 3:52 p. m.

The maximum amplitude of motion in the east-west direction was only about one-fiftieth of an inch.

The earthquake recorded as above is undoubtedly the same as one that is reported to have occurred in the island of Jamaica at the same date and hour. The press reports are as yet very indefinite as to the time when the earthquake occurred at Kingston. By the use of well-known seismological formulas we may deduce, from the records made at Washington, that at its origin this earthquake began at 3 hours 33 minutes 9 seconds, p. m., seventy-fifth meridian time, January 14.

Judging from the magnitude of the motion as recorded at Washington we regard the present disturbance as of slight intensity when compared with other recent great earthquakes, such as those at San Francisco and Valparaiso, and that in the Indian Ocean on October 1, 1906. This is especially true in view of the fact that the distance of Kingston from Washington is only about 1420 miles, while San Francisco is distant 2435 miles, and Valparaiso 4900 miles, or nearly three and a half times as far as Kingston, and both Kingston and Valparaiso are almost exactly south of Washington. The amplitude of the motion at Washington, in the present case, is distinctly less than in either of these other great earthquakes, and we may therefore conclude that the violence of the "Kingston earthquake" was also less at its origin.

Attention is called to an interesting feature in these earthquake records, which confirm, in a noticeable degree, certain theories that have been advanced in regard to the different kinds of wave motion that occur during an earthquake. Kingston and Washington are very nearly on the same geographical meridian, Kingston being only 15 minutes of arc east of Washington, at a distance of something over 1400 miles. In other words the direct line of propagation was, in this case, exactly from south to north. The two seismograph pendulums at Washington are so placed as to record north-south and east-west components, respectively.

The details of the several phases characteristic of records of distant earthquakes are given in the following table:

Kingston earthquake, afternoon of January 14, 1907, seventy-fifth meridian time.

TIME OF EARTHQUAKE.

	N.-S. component.	E.-W. component.
	h. m. s.	*h. m. s.*
First preliminary tremors began January 14, 1907, at	3 38 23	Absent.
Second preliminary tremors began at	3 42 50	3 42 50
Principal portion began at	3 46 45	3 46 38
Principal portion ended at	3 55 03	3 55 03
End of earthquake at	4 40 23	4 49 23

DURATION OF PHASES.

	h. m. s.	*h. m. s.*	
Duration of first preliminary tremors	0 04 27	Absent.	
Duration of second preliminary tremors	0 03 55	0 03 48	
Duration of principal portion	0 08 18	0 08 25	
Total duration of earthquake	1 02 00	1 06 33	
Period of pendulum	20 secs.	20 secs.	
Magnification of record	25 times.	20 times.	
Maximum double amplitude of actual displacement of the earth at the seismograph	*mm.*	*mm.*	
	Amount	0.11	0.55
	Time	$3^h\ 54^m$	$3^h\ 50^m$ / $3^h\ 51^m$

NOTES.—*North-south component:* The period of the waves in the first portion of the "principal portion" was about 10 seconds, with very small amplitude, followed by complex waves of small amplitude beginning at 3:50:23 p. m., of 17-second periods; again followed by waves of shorter period and small amplitude.

East-west component: The first preliminary tremors appear to be absent. The second preliminary tremors are very faint, but appear to begin simultaneously with the second preliminary tremors in the north-south component. The periods in the principal portion are about 10 seconds at first; then complex and long, 20 to 30 seconds; then, from 3:48 to 3:50 p. m., large and regular, at about 20-second periods, ending with maximum waves of 10- to 12-second periods.

Now the record of the "first preliminary tremor" in the north-south direction began at Washington at 3 hours, 38 minutes, 23 seconds, followed by the "second preliminary tremors" 4 minutes and 27 seconds later; the "principal portion", or large motions, began about eight and a half minutes later than the beginning of the "first preliminary tremors". During all this period of eight and a half minutes during which motions were distinctly recorded in the north-south direction, there was an almost total absence of "preliminary tremors" in the east-west direction. Nevertheless, the "principal portion" of the earthquake record at Washington began very abruptly in the east-west component at practically the same instant of time that it began in the north-south component. In addition to this, the amplitude of the east-west motion averaged about five times greater than that of the north-south component.

These results are entirely explained if we assume that the "preliminary tremors", especially the early portions, are longitudinal or compressional waves only; that is the motions of the ground take place directly in the line of propagation, which, in this case, was almost exactly north and south, and therefore affected only the pendulum that records the north-south component, but not the east-west component. Furthermore, the relatively great magnitude of the east-west vibrations appears to be explained on the assumption that in general the stronger motions of the earthquake are surface vibrations transverse to the direction of propagation; in the present case these stronger transverse vibrations were in a strictly east-west direction.

Theories have already been put forth classifying the vibrations of earthquake motions in accordance with the foregoing ideas, but the writer is not aware that a real earthquake of considerable magnitude has ever been actually recorded at stations so favorably located as Kingston and Washington to bring out a full confirmation of the theory.

At this time (January 22) we do not know whether the records of the two seismographs at Cheltenham (a little east of Washington) show such peculiarities as to allow of similar deductions.

THE GEODETIC INSTITUTE AT POTSDAM.

The activity of the Royal Geodetic Institute at Potsdam and of the International Institute which has its center there, covers many items in which meteorologists are interested, such as the size and shape of the earth, the orography of its surface, and the variations in gravity and latitude all of which are closely related to the dynamics of the atmosphere. The annual report of the institute for the year ending April, 1906, submitted by Prof. Dr. Robert Helmert, mentions the following, among other items.

(1) An appreciative notice of the admirable map of Japan made between 1800 and 1818 by T. Ino, a learned Japanese, who knew nothing of European languages and probably very little of European methods. Up to his fiftieth year he was employed as a brewer. He then devoted six years to the study of astronomy, and in his fifty-sixth year undertook this great geodetic work, which he finished after eighteen years of steady labor. A comparison with modern work shows that his geographic latitudes, determined with the crudest instruments, are accurate to within one minute of arc.

(2) The determination of the intensity of gravity at numerous stations in Europe, and especially the absolute determination at Potsdam has occupied a very large amount of attention.

(3) The international latitude service has progressed steadily since 1900, and six continuous years of work are now available for determining the irregular motions of the axis about which the earth rotates, which motions, according to some authorities, are largely the result of meteorological processes. Five stations in the Northern Hemisphere and two in the Southern Hemisphere are now maintained by the International Geodetic Association, and several other stations have voluntarily undertaken such work at their own expense. This work involves the determination of the latitude on every clear night continuously for several years, and the accuracy of the work must be such that a change of five feet in latitude shall be detected. Therefore this latitude work will determine in absolute measures those changes on the earth's surface for which the seismograph gives only relative measures.

(4) By comparing atmospheric pressures measured by mercurial barometers with pressures determined by means of the thermometric boiling point apparatus we are able to determine the force of gravity; and this method, which at first appeared crude, has been brought to such perfection by the labors of the Geodetic Institute that it promises to give us some idea of the variations of gravity over the surface of the ocean, for which hitherto we have had no determinations whatever. The observations made over the Indian and Pacific oceans are now in the course of computation. Whatever the outcome of this particular work may be there is no doubt but that it has already led to very great improvements in methods of determining the boiling point, and has stimulated the more accurate determination of vapor pressures at different temperatures.[1]

(5) The levelings of high precision, together with the determination of the average sea-level surface serving as the basis for all accurate hypsometry, are in the hands of the Geodetic Institute, whose work in this line rivals in importance that of the United States Coast and Geodetic Survey.

(6) The relative movements of the earth's crust, as shown by observations of a horizontal pendulum, have been recorded continuously since January, 1904, in an underground chamber, about eighty feet below the ground, near the buildings of the Geodetic Institute, at Potsdam.

(7) As to seismology, proper, the astatic pendulum of Wiechert and the horizontal pendulum in the special earthquake observatory at Potsdam have been kept in continuous action.

(8) In the special report of Professor Doctor Hecker on earthquake observations he states that the tremors of the earth recorded during the years 1904 and 1905 have been submitted to an investigation with reference to their possible connection with some meteorological factor, and it is found that the amplitudes of those movements of the soil that have a period of about thirty seconds of time run parallel to the strength of the wind.[2] Professor Doctor Hecker also adds that the records of previous earthquakes have been examined to ascertain whether any movement of the soil could be detected as the effect of an earthquake wave reaching the station not by the shortest route from the earthquake center but by the longest route around the earth. He states that in many cases this has been possible, and thus the progressive velocities of the earthquake waves have been more accurately determined.

(9) The accuracy with which time was kept by the Riefler normal clock, with nickel-steel pendulum, in an inclosure at constant pressure, is shown by the table published by Doctor Wanach, from which it appears that a change of 1° C. in

[1] The new edition of Landolt and Börnstein's Tables, Berlin, 1905, gives us, in Tables 57-60 for the first time, the vapor tensions over ice from —50° to 0° C., the tension over water from —20 to 0° C., and the tension over water from 0° to 100° C., corrected for various sources of error and reduced uniformly to the international hydrogen thermometer scale, instead of the normal mercurial thermometer scale used by Reaumur. The tensions below 0° C. are those of Marvin and Juhlin.—ED.

[2] Observations in Washington show that the pressure of the wind against the walls of the building alters the distribution of the pressure within the soil so as to affect the piers upon which the seismograph is placed. As the movements of the pier are magnified from ten to a hundred times, depending upon the adjustments of the seismograph, these movements due to the wind can generally be easily distinguished from those due to an earthquake, but periodic movements of soil, pier, and pendulum are inextricably confused together.